# Enhanced Water Quality Monitoring and Modeling Program for the A.R.M. Loxahatchee National Wildlife Refuge
## Quarterly Update Report – July 2008

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Overview

This update is a summary of activities since the previous status report of April 2008 on the implementation of the Refuge's Enhanced Water Quality Monitoring and Modeling Program. A project overview, and other detailed information about the program can be found at: http://sofia.usgs.gov/lox_monitor_model/. The primary objective of this overall program focuses on providing information for use in ecological management of the Refuge (Brandt et al. 2004; Harwell et al. 2005; USFWS 2007a, b).

The Refuge's monitoring component of this program also addresses one of the Consent Decree Principals recommendations (17 December 2003):

> ***B. Enhancing Monitoring of the Refuge***
> *Design and implement an enhanced monitoring program to improve spatial and temporal understanding of factors related to phosphorus dynamics.*

The Refuge's modeling component of this program also addresses several of the Consent Decree Principals recommendations (17 December 2003):

> ***C. Modeling of the Refuge***
> *1. Develop a water quality/hydraulic model for the Refuge with a phosphorus cycling component.*
> *2. Evaluate issues associated with phosphorus loads and transports within the L-40 and L-7 canals.*
> *3. Develop and track a simple phosphorus mass-balance model for the Refuge.*

Information Availability

Through collaboration with USGS, information from the Refuge's Enhanced Water Quality Monitoring and Modeling Program has been made available on the USGS' SOFIA web site at: http://sofia.usgs.gov/lox_monitor_model/.

Final data for monthly samples through May 2006 are publicly posted on DBHYDRO by the SFWMD at http://www.sfwmd.gov/org/ema/dbhydro/index.html. Data for June 2006-June 2008 are posted on the Technical Oversight Committee's web site at http://www.sfwmd.gov/org/ema/toc/index.html. This report includes information from samples collected through June 2008.

Water Quality Data Analyses Update

Primary efforts for this quarter involved exploring mechanisms to continue translating information from the program to aid in Refuge management decisions.

Two peer-reviewed journal articles from the Enhanced Water Quality Monitoring and Modeling Program were published in early 2008 (Harwell et al., 2008; Surratt et al., 2008). A third journal article was accepted for publication (Wang et al., In Press).

Monitoring Update (April 2008 – June 2008)

Sampling of the enhanced water quality monitoring network (**Figure 1**) occurred at 25 stations in April 2008, 6 stations in May 2008, and 9 stations in June 2008 (**Table 1**).

Total phosphorus data available to date for October 2007 to June 2008 are presented in **Table 1**. Maps of stations where samples were collected for April 2008 through June 2008 are presented in **Figures 2-4**.

Conductivity sonde deployment information for October 2007 to June 2008 is presented in **Table 2**.

Modeling Update

Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge). Two very different, but synergistic, modeling approaches are being pursued. First, an approach assuming a compartmental model design with completely mixed flow within each compartment is providing efficient and flexible models. Second, a spatially explicit complex two-dimensional hydrodynamic and water quality model is under development using commercial modeling software, MIKE FLOOD (DHI Water & Environment).

Drs. William Walker, Robert Kadlec, and Matt Harwell visited the University of Louisiana at Lafayette campus from March 31 to April 2 to review modeling progress, and provide advice on future development. Their advice drove much of the activity in the months following that visit.

The compartmental model is being developed using two different compartmental designs – a 4-compartment, and a 9-compartment design. Calibration of the 4-compartmental model continued during this period using suggestions from Drs. Kadlec and Walker concerning the phosphorus and sulfate model kinetics. The 9-compartment model was under development during this period.

During this reporting period, work began on revising the MIKE FLOOD model to simulate regulatory releases based on the Refuge regulation schedule, rather than using only a historic time series of outflows. Implementation of this simulated management was complex within the constraints of the software, but was achieved.

Sherif Abdou, a graduate student working with the team, continued a student project implementing the MIKE-SHE linked surface-groundwater model for the Refuge. His work will test the sensitivity of surface water stage to groundwater interaction and more complex evapotranspiration modeling.

Next Steps

The next steps for this program include continuation of data collection and analysis, continued work on the next Annual Reporting, and additional model development and application. Additionally, data, analyses and modeling from this program will be presented as part of the A.R.M. Loxahatchee National Wildlife Refuge's Annual Science Workshop being held in conjunction with the July/August 2008 Greater Everglades Ecosystem Restoration Conference in Naples, FL.

References

http://sofia.usgs.gov/lox_monitor_model/

Brandt, L.A., Harwell, M., Waldon, M. (2004) Work Plan: Water Quality Monitoring and Modeling for the A.R.M. Loxahatchee National Wildlife Refuge: 2004-2006. Prepared for the A.R.M. Loxahatchee National Wildlife Refuge. April, 2004. 33 pp.

Chen, C., Meselhe, E. A., Waldon, M. G., Wang, H., and Harwell, M. C. (2008). "Hydrodynamic and Water Quality Modeling of the A.R.M. Loxahatchee Refuge, North Everglades, Florida." *2nd USGS Modeling Conference*, Orange Beach, Alabama.

Harwell, M. Surratt, D., Waldon, M., Walker, B., Brandt, L. (2005) A.R.M. Loxahatchee National Wildlife Refuge Enhanced Water Quality Monitoring and Modeling Interim Report. April, 2005. 106 pp.

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Surratt, D. D., Waldon, M. G., Harwell, M. C., Aumen, N. G. (2008) Time-series and spatial tracking of the intrusion of polluted canal water into wetlands of a National Wildlife Refuge in Florida, USA, USA (Florida, USA). Wetlands. 28(1): 176-183.

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Wang, H., Waldon, M. G., Meselhe, E. A., Arceneaux, J. C., Chen, C., and Harwell, M. C. (2008). "Modeling Surface Water Sulfate Dynamics in a Northern Everglades Wetland." *2nd USGS Modeling Conference*, Orange Beach, Alabama.

Wang, H, Waldon, M. G., Meselhe, E. A., Arceneaux, J. C., Chen, C., Harwell, M. C. (In Press) Surface Water Sulfate Dynamics and Sulfate Reduction in the Northern Florida Everglades, USA. Journal of Environmental Quality.

**Table 1.** Total phosphorus data (ppb) available for October 2007 – June 2008 from the Enhanced Water Quality Monitoring Program for: (a) marsh, and (b) canal stations for the A.R.M. Loxahatchee National Wildlife Refuge. Graphical representation of station locations is shown in Figure 1.

a) Marsh stations

| Marsh Station | Oct-07 | Nov-07 | Dec-07 | Jan-08 | Feb-08 | Mar-08 | Apr-08 | May-08 | June-08 |
|---|---|---|---|---|---|---|---|---|---|
| LOXA101 | 4 | R | 4 | 6 | 11 | 15 | | | |
| LOXA102 | U | R | 5 | 10 | 10 | 9 | | | |
| LOXA103 | 5 | R | U | 5 | 9 | 8 | | | |
| LOXA105 | 12 | R | 8 | 8 | 16 | 17 | | | |
| LOXA106 | U | R | 5 | 7 | 10 | 10 | | | |
| LOXA107 | 11 | R | U | U | 6 | - | | | |
| LOXA108 | U | R | U | U | 9 | 6 | | | |
| LOXA109 | U | R | 7 | 10 | 8 | 20 | 18 | | |
| LOXA110 | U | R | U | U | 7 | 6 | | | |
| LOXA111 | U | R | 11 | U | 11 | 5 | 3 | | |
| LOXA112 | 6 | R | U | 8 | 9 | 15 | 6 | | |
| LOXA113 | U | R | 13 | U | 3 | 11 | 14 | | |
| LOXA114 | U | R | 5 | 5 | 4 | 6 | 6 | | |
| LOXA116 | 59* | R | 110 | 46 | 48 | 120 | 69 | | |
| LOXA117 | 12 | R | 18 | 12 | 13 | 14 | | | |
| LOXA118 | U | R | 11 | 6 | 9 | 9 | 6 | | 11 |
| LOXA119 | 4 | R | 8 | 7 | 12 | 7 | 6 | | 7 |
| LOXA120 | 5 | R | 9 | 6 | 6 | 7 | 7 | 100 | 5 |
| LOXA121 | X | X | X | X | X | X | X | X | X |
| LOXA122 | 6 | R | 15 | 8 | 9 | 13 | 14 | | |
| LOXA123 | X | X | X | X | X | X | X | X | X |
| LOXA124 | 7 | R | 13 | 9 | 8 | 7 | 4 | | |
| LOXA126 | U | R | 11 | 16 | 7 | 8 | 8 | | |
| LOXA127 | U | R | 8 | 5 | 6 | 11 | 4 | | |
| LOXA128 | U | R | 5 | U | 15 | 12 | 4 | | |
| LOXA130 | 7 | R | 11 | 10 | 8 | 12 | 10 | | 16 |
| LOXA131 | U | R | 7 | 7 | 7 | 8 | 7 | | |
| LOXA133 | 120* | R | 35 | 19 | 29 | 16 | | | |
| LOXA134 | 6 | R | 13 | 8 | 18 | 11 | 10 | | |
| LOXA136 | 18 | R | 20 | 9 | 17 | 13 | | | |
| LOXA137 | 10 | R | 12 | 6 | 16 | 10 | 13 | | |
| LOXA138 | U | R | 4 | 5 | 8 | 8 | 8 | | |
| LOXA139 | U | R | 8 | U | 9 | 4 | | | |
| LOXA140 | 53* | R | 10 | 6 | 10 | 10 | | | |
| LOXA141 | 6 | R | 6 | 6 | 10 | 16 | 8 | | |
| MAX | 120 | | 110 | 46 | 48 | 120 | 69 | 100 | 16 |
| MIN | 4 | | 4 | 5 | 3 | 4 | 3 | 100 | 5 |

U indicates that compound was analyzed but not detected; - = no sample collected
X indicates station no longer sampled; R = data rejected
* sample was re-analyzed sample. Oct-07 = 81 ppb; LOXA133 , Oct-07 = 120 ppb; LOXA140, Oct-07 = 12 ppb.

**Table 1 cont.**

b) Canal stations

| Canal Station | Oct-07 | Nov-07 | Dec-07 | Jan-08 | Feb-08 | Mar-08 | Apr-08 | May-08 | June-08 |
|---|---|---|---|---|---|---|---|---|---|
| LOXA104 | 35 | R | 37 | 26 | 37 | 35 | 24 | 44 | 54 |
| LOXA115 | 34 | R | 20 | 22 | 27 | 27 | 18 | 26 | 33 |
| LOXA129 | 13 | R | 41 | 24 | 40 | 18 | 34 | 49 | 37 |
| LOXA132 | 13 | R | 36 | 28 | 35 | 21 | 29 | 40 | 31 |
| LOXA135 | 9 | R | 34 | 25 | 33 | 19 | 32 | 40 | 26 |
| MAX | 35 | | 41 | 28 | 40 | 35 | 34 | 49 | 54 |
| MIN | 9 | | 20 | 22 | 27 | 18 | 18 | 26 | 26 |

U indicates that compound was analyzed but not detected.

**Table 2.** October 2007 – June 2008 conductivity sonde deployment information, separated by transect, for the A.R.M. Loxahatchee National Wildlife Refuge. X = data collected from sonde deployment during that month. Graphical representation of station locations is shown in Figure 1.

| | | | | 2008 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site ID | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun |
| LOXA104 | X | X | | X | X | X | X | X | X |
| LOXA105 | | X | | X | | X | | X | |
| LOXA106 | | X | | X | | X | | X | |
| LOXA107 | | X | | X | | X | | X | |
| LOXA108 | | X | | X | | X | | X | |
| LOXA111 | X | | X | | X | | X | | X |
| LOXA112 | X | | X | | X | | X | | X |
| LOXA113 | X | | X | | X | | X | | X |
| LOXA114 | X | | X | | X | | X | | X |
| LOXA115 | X | X | | X | X | X | X | X | X |
| LOXA116 | X | | X | | X | X | | | |
| LOXA117 | X | | X | | X | X | | | |
| LOXA118 | X | | X | | X | X | | | |
| LOXA119 | X | | X | | X | X | | | |
| LOXA120 | X | | X | | X | X | | | |
| LOXA126 | X | | X | | X | | X | | X |
| LOXA127 | X | | X | | X | | X | | X |
| LOXA128 | X | | X | | X | | X | | X |
| LOXA129 | X | X | | X | X | X | X | X | X |
| LOXA130 | | X | | X | | X | | X | |
| LOXA131 | | X | | X | | X | | X | |
| LOXA132 | X | X | | X | X | X | X | X | X |
| LOXA133 | | X | | X | | X | | X | |
| LOXA135 | X | X | | X | X | X | X | X | X |
| LOXA136 | | X | | X | | X | | X | |
| LOXA137 | | X | | X | | X | | X | |
| LOXA138 | | X | | X | | X | | X | |
| LOXA139 | | X | | X | | X | | X | |
| LOXA141 | | | | | | | | | |
| LOXA142 | | | X | X | | | X | | |
| LOXA143 | X | | X | | X | | X | | X |
| LOXA144 | X | | X | | X | | X | | X |
| LOXA145 | X | | X | | X | | X | | X |
| LOXA146 | X | | X | | X | | X | | X |
| LOXA147 | X | | X | | X | | X | | |
| LOXA148 | X | | X | | X | | X | | X |
| LOXA149 | X | | X | | X | | X | | X |
| LOXA150 | X | | X | | X | | X | | X |
| LOXA151 | X | X | X | X | | X | | X | X |
| LOXA152 | X | X | X | X | | X | | X | X |
| LOXA153 | X | X | X | X | | | | X | X |
| I-8C | X | X | | X | X | X | | X | X |
| LOX04 | | | | X | | X | | X | |
| LOX06 | X | X | X | | X | | X | | X |
| LOX07 | X | X | X | | X | | X | | X |
| LOX08 | X | X | X | | X | | X | | X |
| LOX09 | X | X | X | | X | | X | | X |
| LOX10 | X | X | X | | X | | X | | X |
| LOX15 | X | X | X | | X | | X | | X |

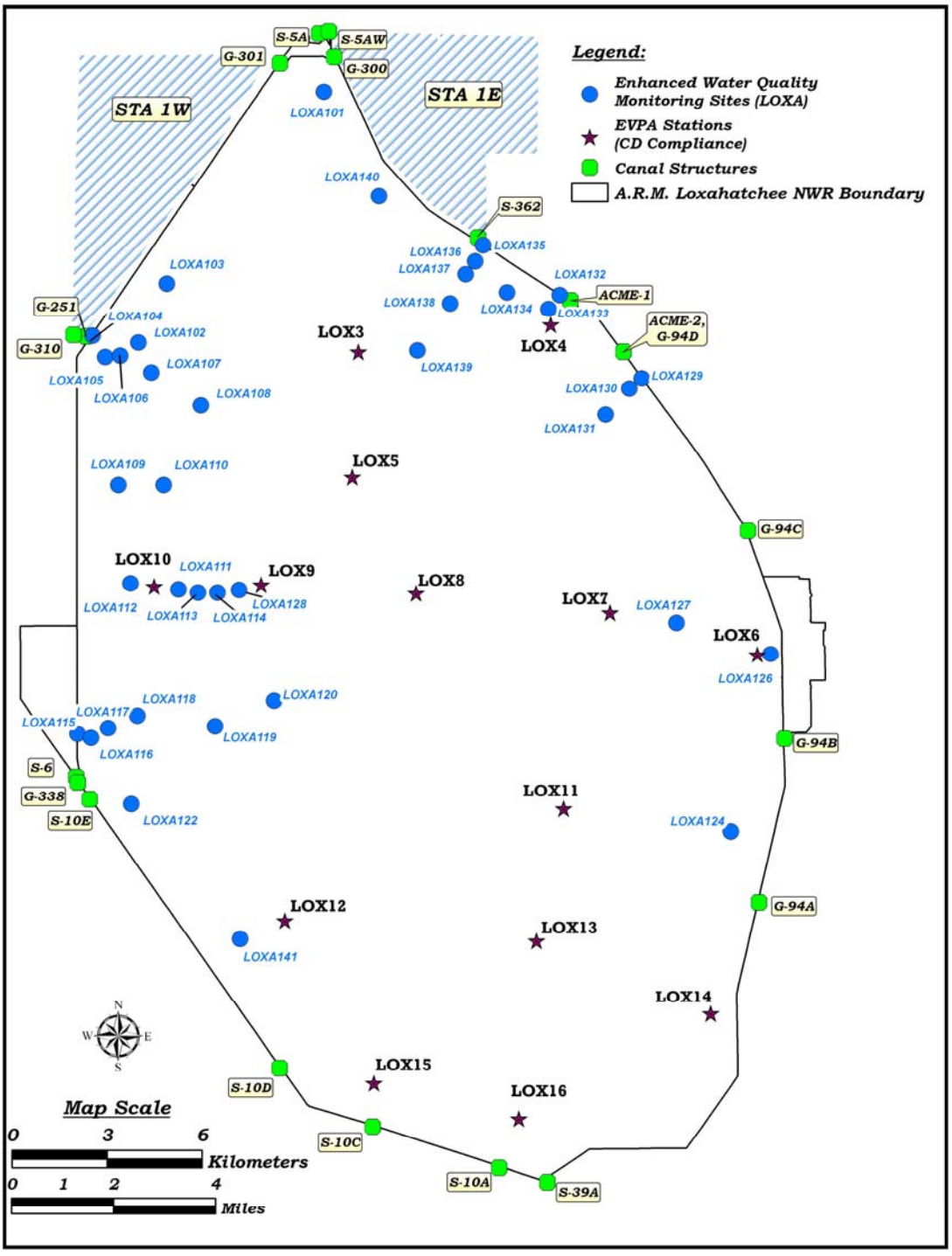


**Figure 1.** Location of Enhanced Water Quality Monitoring network stations (LOXA###), in relation to Consent Decree compliance stations (LOX##), for the A.R.M. Loxahatchee National Wildlife Refuge.

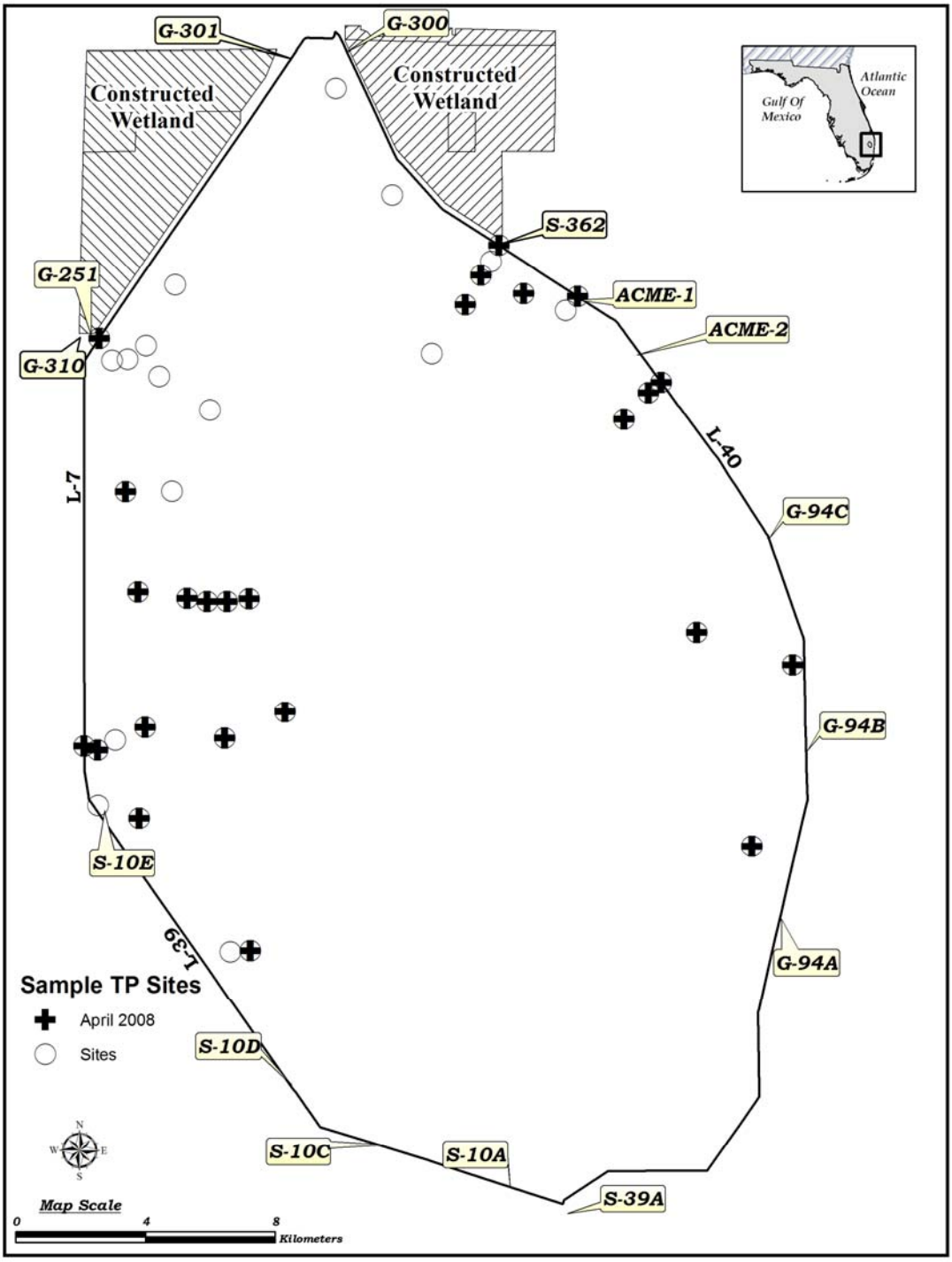


**Figure 2.** April 2008 map of total phosphorus sample collections from the Enhanced Water Quality Monitoring and the EVPA stations in the A.R.M. Loxahatchee National Wildlife Refuge. A primary reason that a station is not sampled is that it has less than 10 cm of clear water column representative of that area.

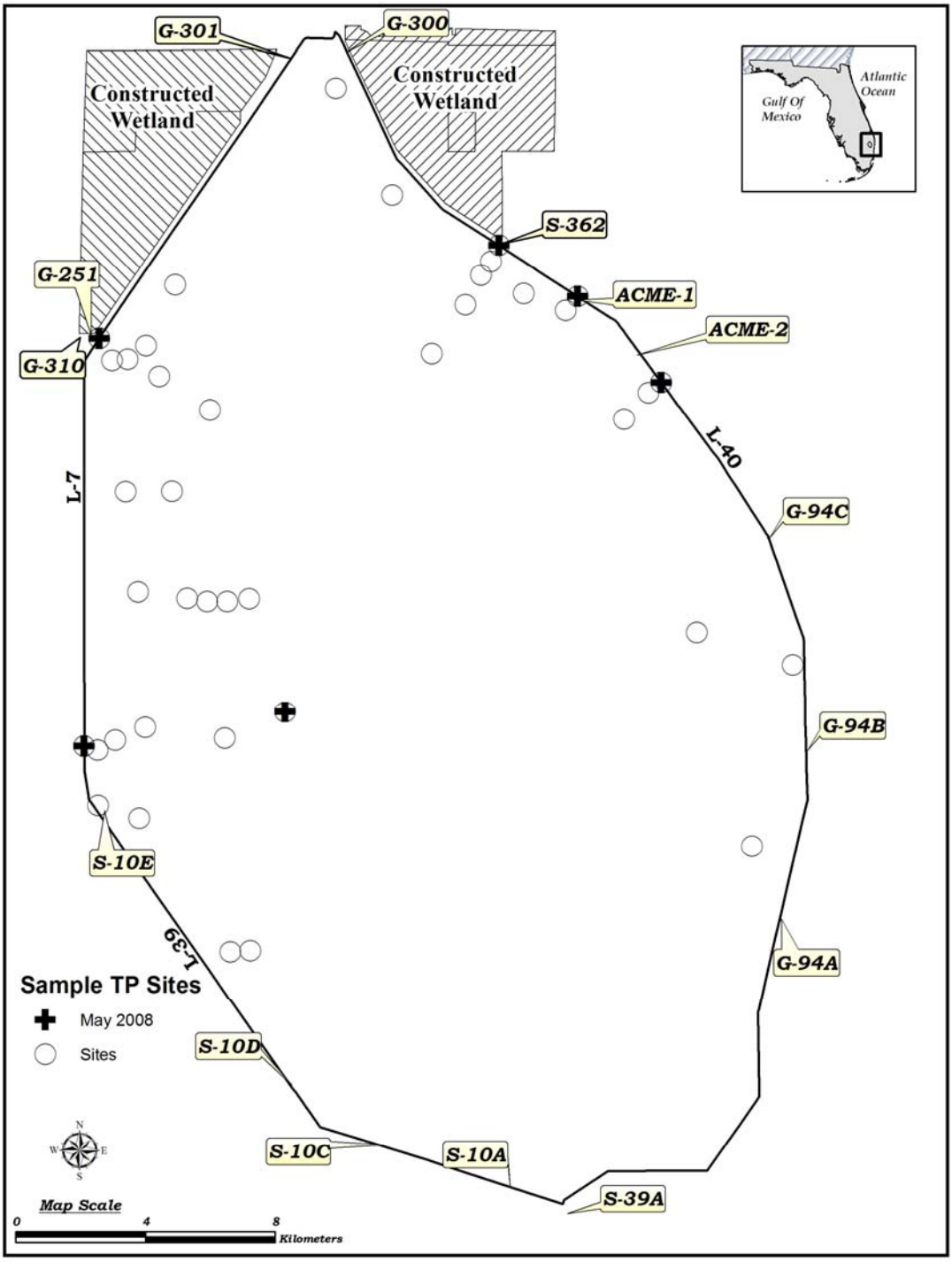


**Figure 3.** May 2008 map of total phosphorus sample collections from the Enhanced Water Quality Monitoring and the EVPA stations in the A.R.M. Loxahatchee National Wildlife Refuge. A primary reason that a station is not sampled is that it has less than 10 cm of clear water column representative of that area.

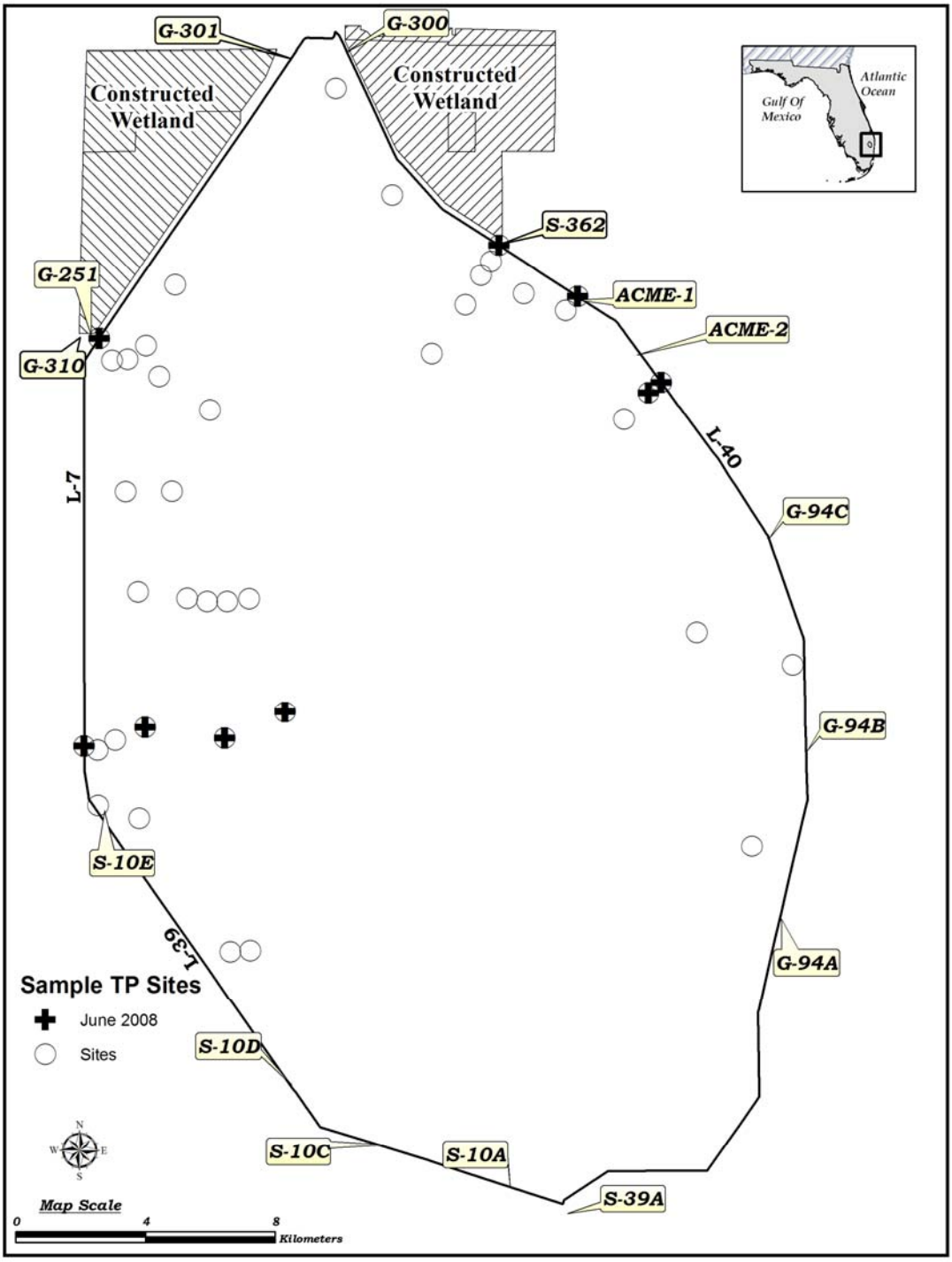


**Figure 4.** June 2008 map of total phosphorus sample collections from the Enhanced Water Quality Monitoring and the EVPA stations in the A.R.M. Loxahatchee National Wildlife Refuge. A primary reason that a station is not sampled is that it has less than 10 cm of clear water column representative of that area.